SINGER
INSTRUMENTATION

# INSTRUCTION MANUAL FOR COMPLEX RATIO BRIDGE MODEL CRB–4

MANUAL NO. 1–500783–023

2-C-83

# INSTRUCTION MANUAL
# FOR
# COMPLEX RATIO BRIDGE
# MODEL CRB–4

MANUAL NO. 1–500783–023

(FOR SERIAL NUMBERS 267 & UP)

Reprinted 6/77 Lib

SINGER
INSTRUMENTATION

The Singer Company, Los Angeles Operation • 5340 Alla Road, Los Angeles, Ca. 90066

GERTSCH PRODUCTS, INC.
3211 So. LaCienega Blvd
Los Angeles 16, California

# DIFFFRENCE DATA SHEET
## MODEL CRB-5 800 cps
## COMPLEX RATIO BRIDGE

The instructions and specifications (see page 4) included in the Model CRB-4 Instruction Book apply except for the specific differences noted below.

The Model CRB-5 differes from the Model CRB-4 in the following respects:

1. Bandpass filter FL100 is included in the null amplifier as shown on the attached schematic. Although the bridge nulls only to the fundamental component of the incoming signal, the harmonic and noise content of the incoming signal can obscure the null points. With the addition of the filter, the harmonic and noise content is greatly reduced and more accurate null indications can be obtained.

2. Variations from the center frequency of 800 cps can result in phase shift through the filter. To compensate for phase shifts, PHASING potentiometer R169 and capacitor C135 are included in the input circuit to the filter.

3. IN-PHASE RATIO range switch S112 is eliminated and only the X1 inphase ratio range is available.

4. For 800 cps operation, the values of capacitors C121, C122, C135, and C136 are selected (approximately 1/2 of the 400 cps value) to adapt frequency sensitive circuits.

OPERATING INSTRUCTIONS, THEORY OF OPERATION, AND MAINTENANCE instructions are the same except as follows:

Following step 6 of the OPERATING INSTRUCTIONS, adjust PHASING control as follows:

a. Connect the signal input probe to the ground side of the reference input. If the reference ground is connected to the signal ground, simply apply the probe to the case.

b. Turn the IN-PHASE/QUADRATURE switch to the IN-PHASE position.

c. Adjust the IN-PHASE ratiotran controls as required to obtain full scale deflection (end of meter graduations) on the null meter.

d. Note the reading of the IN-PHASE ratiotran controls and set the controls to twice this reading.

NOTE

This provides an inphase signal which is large enough for detection of phase shift and yet small enough to avoid everdriving the null amplifier.

DIFFERENCE DATA SHEET
MODEL CRB-5 800 cps

e. Turn IN-PHASE/QUADRATURE switch to the QUADRATURE position.

f. Adjust PHASING control as required to obtain a center null on the null meter.

g. Disconnect probe from the ground side of the reference input and proceed with step 7 of the OPERATING INSTRUCTIONS.

PARTS LIST CHANGES

| SYMBOL | CHANGE | DESCRIPTION | MANUFACTURER | PART NO. |
|---|---|---|---|---|
| C109 | Delete | | | |
| C121 | Change | Capacitor, silvered mica 2200 pf (nom. value) | | |
| C122 | Change | Capacitor, polystyrene (.016 uF (nom. value) | | |
| C134 | Add | Capacitor, electrolytic 15 uf, 12 vdc | Sprague | TE1129 |
| C135 | Add | Capacitor, paper .025 uf 200 vdc (nom. value) | | |
| C136 | Change | Capacitor, mica 75 pF (nom. value) | | |
| FL100 | Add | Filter, bandpass | Gertsch | BPF-800-N |
| R169 | Add | Potentiometer, composition, 5 K | Gertsch | RV42-2 |
| R170 | Add | Resistor, composition 10 K ±10% 1/2 W | | |
| S112 | Delete | | | |

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Los Angeles 16, California

# DIFFERENCE DATA SHEET
# MODEL CRB-5 400 CPS OPERATION
# COMPLEX RATIO BRIDGE

The instruction and specifications included in the Model CRB-4 Instruction Book apply excpet for the specific differences noted below.

The Model CRB-5 differes from the Model CRB-4 in the following respects:

1. Bandpass filter FL100 is included in the null amplifier as shown on the attached schematic. Although the bridge nulls only to the fundamental component of the incoming signal, the harmonic and noise content of the incoming signal can obscure the null points. With the addition of the filter, the harmonic and noise content is greatly reduced and more accurate null indications can be obtained.

2. Variations from the center frequency of 400 cps can result in phase shift through the filter. To compensate for phase shifts, PHASING potentiometer R169 and capacitor C135 are included in the input circuit to the filter.

3. IN-PHASE RATIO range switch S112 is eliminated and only the X1 in-phase ratio range is available.

OPERATING INSTRUCTIONS, THEORY OF OPERATION, AND MAINTENANCE instructions are the same except as follows:

Following step 6 of the OPERATION INSTRUCTIONS, adjust PHASING control as follows:

a. Connect the signal input probe to the ground side of the reference input. If the reference ground is connected to the signal ground, simply apply the probe to the case.

b. Turn the IN-PHASE/QUADRATURE swith to the IN-PHASE position.

c. Adjust the IN-PHASE ratiotran controls as required to obtain full scale deflection (end of meter graduations) on the null meter.

d. Note the reading of the IN-PHASE ratiotran controls and set the controls to twice this reading.

DIFFERENCE DATA SHEET
MODEL CRB-5 400 cps

NOTE

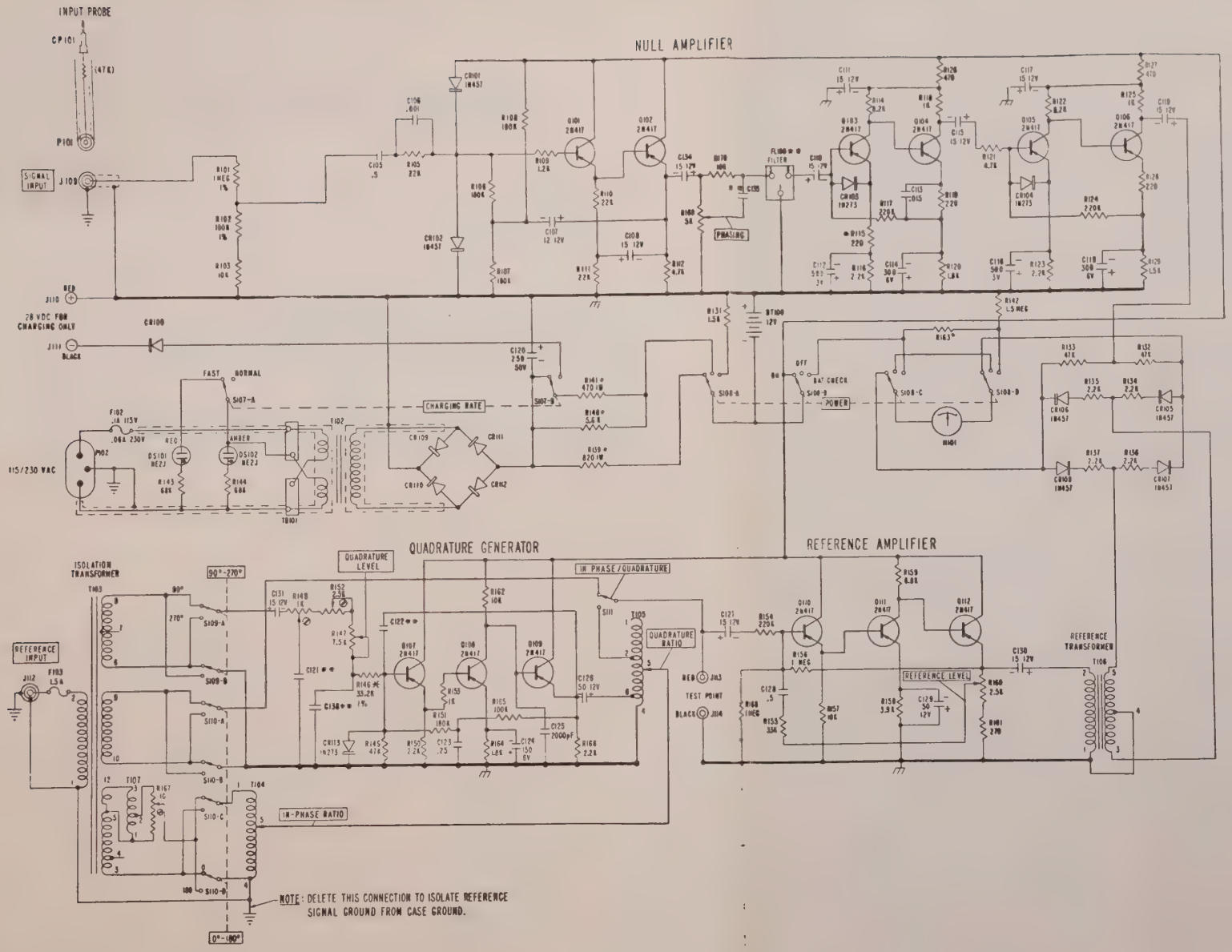
This provides an inphase signal which is large enough for detection of phase shift and yet small enough to avoid overdriving the null amplifier.

e. Turn IN-PHASE/QUADRATURE switch to the QUADRATURE position.

f. Adjust PHASING controls as required to obtain a center null on the null meter.

g. Disconnect probe from the ground side of the reference input and proceed with step 7 of the OPERATING INSTRUCTIONS.

| SYMBOL | CHANGE | DESCRIPTION | MANUFACTURER | PART NO. |
|---|---|---|---|---|
| C109 | Delete | | | |
| C134 | Add | Capacitor electrolytic, 15 uf, 12 vdc | Sprague | TE1129 |
| C135 | Add | Capacitor paper .05 uf 200 vdc | Aerovox | P8292ZN9 |
| FL100 | Add | Filter, bandpass | Gertsch | BPF-400-N |
| R169 | Add | Potentiometer, composition, 5K | Gertsch | RV42-2 |
| R170 | Add | Resistor, composition 10K ± 10% 1/2W | | |
| S112 | Delete | | | |




NOTES:

1. ALL RESISTORS ARE 1/2 WATT AND IN OHMS ±10% UNLESS OTHERWISE SPECIFIED.
2. ALL CAPACITORS ARE IN μF UNLESS OTHERWISE SPECIFIED.
- VALUE SELECTED AT FACTORY (MAY BE OMITTED).

| REF DES | 400 CPS | 800 CPS |
|---|---|---|
| C121 | 4300 pF | 2200 pF (NOM VALUE) |
| C122 | .033 UF | .018 UF (NOM VALUE) |
| C135 | .05 UF | .025 UF (NOM VALUE) |
| C136 | 150 pF | 75 pF (NOM VALUE) |
| FL100 | 8pF 400W | 8pF 800W |

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THE SINGER COMPANY
LOS ANGELES OPERATION
5340 Alla Road
Los Angeles, California 90066

# WARRANTY

THE SINGER COMPANY, LOS ANGELES OPERATION, (SELLER) warrants each new instrument to be free from defects in material and workmanship, effective after delivery to the original purchaser as follows:

| | |
|---|---|
| TCXO Oscillator | 2 Years |
| Electrical and Electronic Measuring Instruments | 1 Year |

Repair or replacement (at our option) without charge (F.O B. factory) will be effected when our examination satisfactorily indicates that defects are due to workmanship or materials. Electron tubes, semiconductors, batteries, fuses, lamps, thermoelements, and RatioTran potentiometers are excluded from warranty coverage. Warranty returns must first be authorized by the factory.

If the instrument or any portion thereof, has been abused, misused, damaged by accident or negligence, or if any serial number or seal has been removed or altered, the warranty is void.

This warranty is in lieu of all other warranties, express or implied INCLUDING THE IMPLIED WARRANTY OF MERCHANTABILITY, or fitness for a particular purpose. In no event shall the SELLER be liable for INCIDENTAL OR CONSEQUENTIAL damages. The SELLER neither assumes, nor authorizes any person to assume for it, any other liability in connection with sales of instruments manufactured by SELLER.

With respect to repairs, the foregoing warranty shall apply for a period of ninety days to the repaired portion.

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5340 Alla Road, Los Angeles, California 90066

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## REPAIR AND MAINTENANCE

Instruments should be returned only on prior authorization from the Singer Representative or the factory. You will be advised of detailed shipping instructions at that time. Return the instrument to the factory Prepaid. Validity of warranty will be determined by the factory.

Chargeable repairs: If requested, an estimate of charges will be made prior to repairs. Please provide us with the following information in order to expedite the processing of your instrument:

1. Model or Type
2. Serial Number
3. Description of trouble(1)
4. Approximate date instrument was placed in operation.
5. Approximate number of hours in use.
6. Has maintenance action been previously requested.
7. Other comments.

(1) Include data on symptoms, measurements taken, suspected location of trouble, maintenance action taken and any other relevant data.

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FIGURE 1. MODEL CRB-4

# SECTION I
# GENERAL DESCRIPTION

The Gertsch Model CRB-4 Complex Ratio Bridge is used to measure the in-phase and quadrature ratios of any three or four terminal network. The unit operates from AC line or an internally mounted battery source.

**NOTE**

If portability is not desired, a simple modification to AC *only* operation will be performed upon customer request. Portions of this manual pertaining to battery operation may be disregarded if this modification has already been incorporated.

The CRB-4 is an AC bridge capable of generating and indicating the complex ratio needed to duplicate a ratio under test. A self contained phase sensitive null detector is used to show when the two ratios are exactly equal.

The complex vector ratio is generated by summing an in-phase ratio (fraction of reference) with a quadrature ratio that is obtained by shifting a portion of the reference voltage by 90°. Switches are provided to make the in-phase ratio 0° or 180° and the quadrature ratio 90° or 270°, all with respect to the reference input voltage. A complex ratio in any of the four quadrants can thus be duplicated and measured.

The indicated ratio is in rectangular coordinates of the form $\pm R \times \pm jRy$.

The vector ratio generated within the CRB-4 is applied to the common terminal of the phase sensitive null amplifier-detector while the complex ratio to be measured is applied to the amplifier-detector input terminal. When the two vectors are exactly equal, there will be no voltage difference between the common and input terminals. The null meter will then indicate a null in either position of the in-phase/quadrature switch. The amplifier chassis itself is the common terminal of the amplifier and for this reason it must be completely floating and isolated from the case and ground. A duplicate of the actual potential of the ratio under test (at null) is present on the chassis.

This method of null detection results in an extremely high input impedance at null. When the amplifier common terminal is at the same AC potential as the input terminal there is no current flow through the input resistor and of course no current flow is representative of an open circuit or infinite input impedance.

The off-null impedance is limited to the one megohm series resistor of the input voltage divider. Fig 2 on page 5 is a graphical presentation of the input impedance as a function of the percentage off-null.

The signal input probe shield is also connected to the common terminal and is therefore 'driven'. At null the signal on the shield is exactly the same as the ratio under test which virtually eliminates all capacity effects between it and center conductor.

A portion of the in-phase reference voltage and of the quadrature voltage are used for the phase-sensitive detector reference. When the quadrature reference is used, the detector is sensitive to only the quadrature component of the null signal and to only the in-phase component when the reference is in-phase.

## SPECIFICATIONS
## GERTSCH MODEL CRB-4 COMPLEX RATIO BRIDGE

1) Max. Signal Input Voltage:
   125 volts, RMS
2) Max. Reference Input Voltage:
   125 volts, RMS
   Minimum Reference Input Voltage:
   20 volts, RMS
3) Frequency:
   400 cps (variable $\pm$ 5%)
4) In-phase Ratio Range:
   2 Ranges 0 - .11110 (6 place res.)
   0 - 1.1110 (5 place res.)
5) Quadrature Ratio Range:
   0 - .11110 (6 place res.)
6) Read Out:
   Rectangular Coordinates (R x $\pm$ Rjy)
7) Sensitivity:
   200 UV per Div of meter scale
8) Input Power
   a. 1.5 watts at 115V/230V (50-1000 cycles)
   b. Internal rechargeable battery on trickle charge during AC operation.
      20 hour operation on battery alone.
9) Accuracy:
   In-phase: Reading $\pm$ .0001
   Quadrature: Reading $\pm$(.001+cal. error+.0002 Rx)
10) Probe Impedance:
    a. At Null: 20,000 megohms shunted by .01 uuf.
    b. Off Null: 1 megohm minimum.
11) Reference Input Impedance:
    Greater than 50K at 400 cycles.
12) Size:
    Std. 19" rack panel, 5¼" high x 14" deep.
13) Weight:
    Approximately 20 pounds.

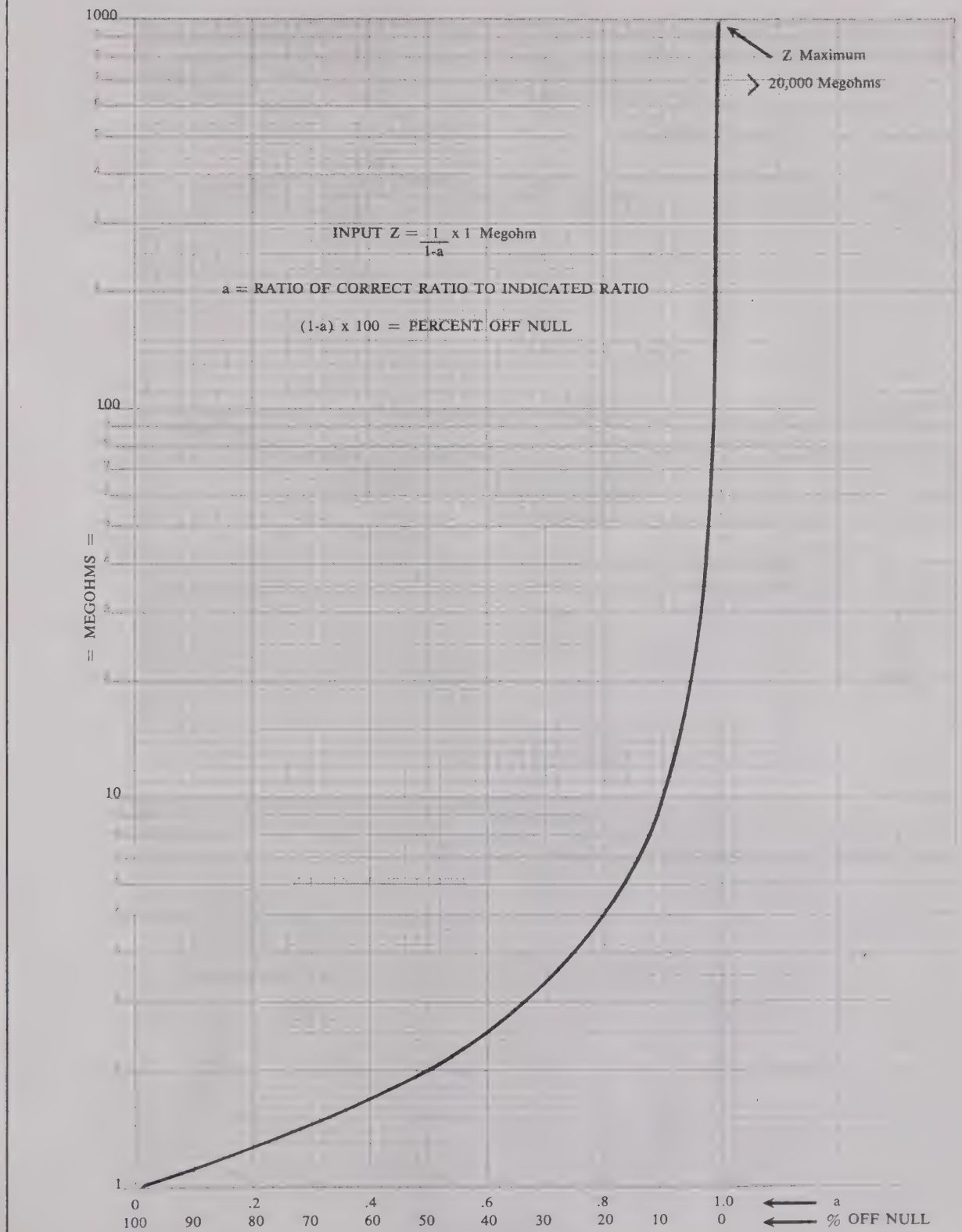



FIGURE 2. GRAPH — INPUT IMPEDANCE

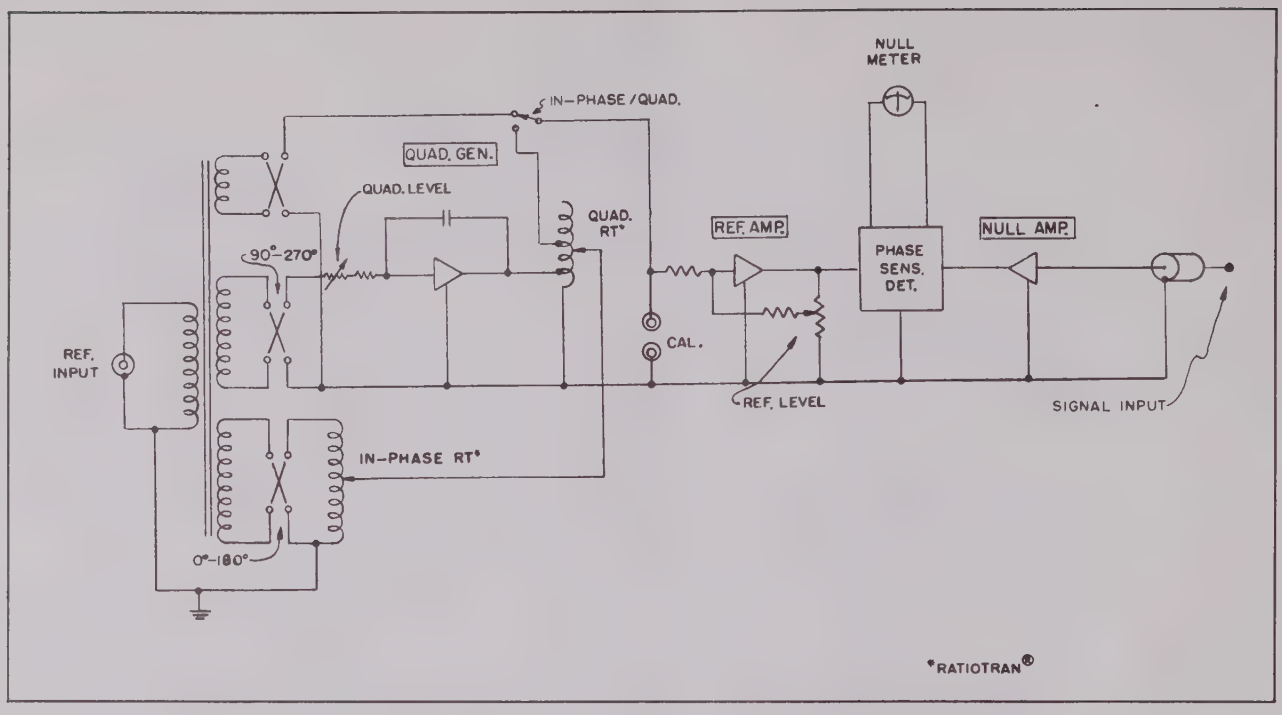



FIGURE 3. BLOCK DIAGRAM

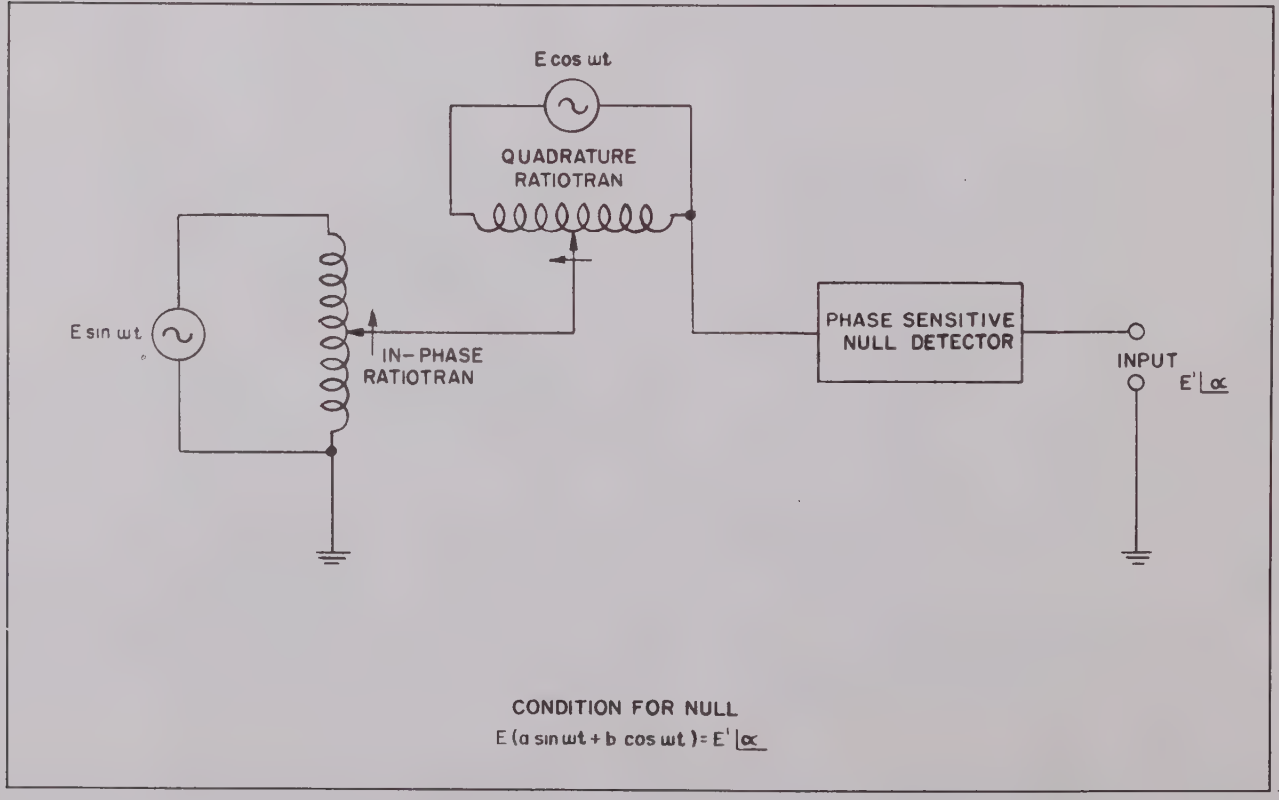



FIGURE 4. SIMPLIFIED BLOCK DIAGRAM

## FUNCTION OF OPERATING CONTROLS AND CONNECTORS

### FRONT PANEL

**IN-PHASE RATIOTRAN®**

Controls and indicates the amount of in-phase voltage used to obtain null. (maximum ratio = 1.1110).

**SIGNAL INPUT**

Probe to connect to 'secondary' of unit under test.

**FAST CHARGE LAMP**

Indicates when battery is connected for fast charge from power line. The battery will only receive fast charge when power switch is in the OFF position.

**IN-PHASE RATIO**

A two position switch to control the amount of REFERENCE applied to the IN-PHASE RATIOTRAN.

**REFERENCE LEVEL**

Control to set the required reference level for the phase sensitive detector.

**90°-270°**

Switch to invert the phase of the QUADRATURE RATIOTRAN for measurements in the third and fourth quadrants.

**IN-PHASE/QUADRATURE**

Switch controlling the phase of the reference voltage applied to the phase sensitive detector. The meter will indicate the in-phase component when in the IN-PHASE position and the quadrature component when in the QUADRATURE position.

**TEST JACKS**

Test jacks for pre-use calibration of the quadrature voltage amplitude.

**0°-180°**

Switch to invert the phase of the IN-PHASE RATIOTRAN for measurements in the second and third quadrants.

**POWER**

A three position switch controlling power to the amplifiers.

a) BAT. CHK. Converts null meter to a voltmeter to measure battery voltage. Meter reading to right of red line indicates satisfactory battery condition.

b) OFF Disconnects power to amplifiers and applies a trickle charge to battery if CRB-4 is connected to power line. This position also used on fast charge.

c) ON Applies power to amplifiers.

**QUADRATURE LEVEL**

Control to adjust the quadrature amplitude in pre-use calibration.

**AC LAMP**

Indicates when CRB-4 is connected to power line.

**QUADRATURE RATIOTRAN**

Controls and indicates the amount of quadrature voltage used to obtain null. (maximum ratio = .11110).

**REFERENCE INPUT**

Connector for signal source. One side is common to the case.

### REAR PANEL

**POWER FUSE — SPARE**

A type 3AG slo-blo fuse in series with the primary of the AC power transformer.

**R152-R148**

Controls for quadrature generator (maintenance only—see text in MAINTENANCE section).

**REFERENCE FUSE — SPARE**

A type 3AG 1.5A slo-blo fuse in series with primary of the isolation transformer.

**RATIO ARM FUSE — SPARE**

A type 3AG .5AMP. slo-blo fuse in series with RatioTran arm.

**FAST CHARGE SWITCH**

A DPDT switch controlling the battery charging rate. When the power switch (front panel) is in the OFF position, the charging current is approximately 5 ma on NORMAL and 40 ma when on FAST CHARGE. The FAST CHARGE lamp indicates the switch position.

**28V CHARGING TERMINALS**

Terminals for applying 28V charging source to battery.

**CAUTION**

DISCONNECT REFERENCE CABLE WHEN USING 28V CHARGING SOURCE TO PREVENT DAMAGING RATIOTRAN.

# SECTION II
# OPERATING INSTRUCTIONS

1. Connect "probe" cable to "signal input" connector on front panel.
2. Connect cable with no termination on one end to "reference input" connector on front panel.
3. Connect unterminated end of the "reference cable" & signal source to "input" of device under test.
4. Set "reference level" control to correspond to input voltage of device under test.
5. Turn "power" switch to "battery check" position. Meter needle should deflect to at least red line. If not, internal rechargeable battery should be recharged. This can be done by connecting the AC power cord from the connector on the rear of unit to appropriate AC source. (NOTE: Battery may also be charged by connecting "28 volt DC" binding posts on rear of unit to "28 volt DC" power source. However, the Bridge may not be operated while charging the battery from 28V source.) After battery is recharged, as indicated by red line deflection with "power" switch in "battery check" position, turn "power" switch to "on".
6. Set in-phase and quadrature RatioTrans to zero. Set "0°/180°" switch to "0°" and "90°/270°" switch to "90°" position. Connect VTVM to terminals immediately below "in-phase/quadrature" switch. With "in-phase/quadrature" switch in the "in-phase" position, note reading on VTVM. Switch "in-phase/quadrature" switch to "quadrature" position and adjust "quadrature level" control for same VTVM reading.

   (NOTE: Exactness of this adjustment is important since a nonequality of these two voltage settings will result in a "quadrature ratio" error.) Disconnect external VTVM.
7. Connect "probe" of signal input cable to output of device under test.
8. With "in-phase/quadrature" switch in "in-phase" position, adjust in-phase RatioTran for null as indicated on front panel meter. (For very small in-phase ratios, the in-phase ratio range switch may be moved to the x.1 position to increase the resolution of final reading.)
9. With "in-phase/quadrature" switch in "quadrature" position, adjust quadrature RatioTran for null.

   (NOTE: With RatioTrans set to zero, meter needle should deflect to the left of center if quadrant switches are in the proper position. If, instead, the needle deflects to the right, the "0°/180°" or the "90°/270°" switches must be reversed.)
10. Repeat Steps 8 and 9 until meter needle remains in center position with "in-phase/quadrature" switch in either position. The in-phase ratio can now be read directly from the in-phase RatioTran dials and the quadrature ratio may be read from the quadrature RatioTran dials.

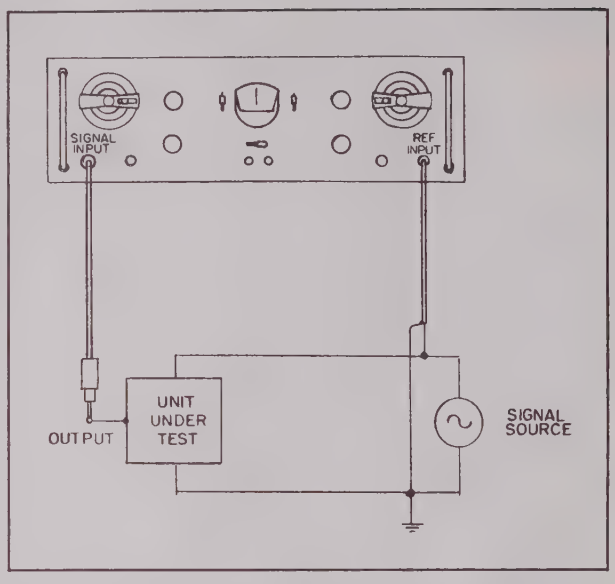



FIGURE 5. TYPICAL MEASUREMENT SET-UP

## QUADRATURE ANGULAR ERROR VS. IN-PHASE RATIO ACCURACY

If the quadrature voltage is not exactly $\pm 90°$, it will contain some in-phase component. When this voltage is used to obtain null, the in-phase component will be inadvertently compensated for by the in-phase RatioTran. The in-phase ratio reading will then be in error by the amount of in-phase signal present in the quadrature used.

In the CRB-4 the quadrature is generated by an operational amplifier connected as an integrator. An explanation of its operation is as follows:

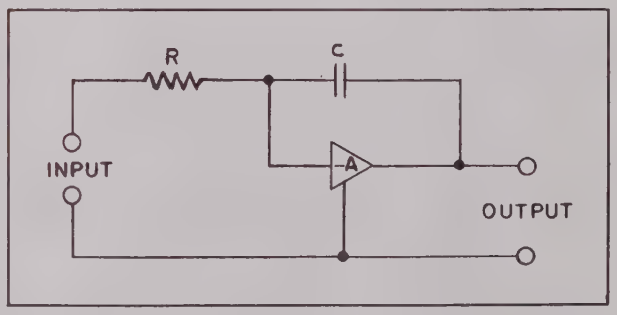



FIGURE 6.

Referring to the block diagram of Fig. 6, R and C form a reactive divider. The values are so chosen to make $1/\omega C = 2R/7$.

This combination alone will produce a phase shift at the junction of the two components (assuming amplifier output $Z = 0$) that is $\phi = \tan^{-1} \omega RC = \tan^{-1} 3.5 = 74° 3'$. The error angle $= 90° - \phi = \alpha = \cot^{-1} \omega RC$. The junction of the two components is also the input to the amplifier. The signal appearing at its input is amplified $-A$ times at the amplifier output. Capacitor "C" is connected between

the input and output of the amplifier and results in the effective value of the capacitance being increased by the open loop gain "A" of the amplifier to AC. With an amplifier open loop gain of 200 the capacitance reactance is reduced by 200. This in turn will reduce the signal appearing at the amplifier input by the same factor. The amplifier output, however, is 200 times the input which is approximately the same level as would exist at the junction without the amplifier connected. The phase $\phi$, will now be $\tan^{-1} A\omega RC = \tan^{-1} 700 \cong 89° 55'$, and the error angle $\propto$ is $\cot^{-1} A\omega RC = \tan^{-1} 1/A\omega RC = \tan^{-1} .00143 \cong 5'$.

An adjustable phase lag network at the input to the quadrature generator is used to compensate for this small error angle $\propto$.

# SECTION III
# THEORY OF OPERATION

### ISOLATION TRANSFORMER

The isolation transformer provides the necessary isolated reference sources for the quadrature generator and detector in-phase reference. It also provides the means to invert the signal with respect to the reference input for operation in all four quadrants.

### QUADRATURE GENERATOR

The quadrature voltage is generated in the amplifier consisting of Q107, Q108, and Q109 connected as an integrator. In such an amplifier, if the ratio of open loop gain to closed loop gain is large, the output is an accurate integral of the input. The integral output with a sine wave input ($\int$ SIN$\omega$t) is $-$COS$\omega$t or the sine wave input shifted by 90°. The amplifier used has an open loop gain greater than 200 and a closed loop gain of .3. The input to the amplifier from the transformer secondary is .07 times the reference input level. This level combined with the amplifier gain of .3 gives an output that is only .02 times the reference input level. To increase the available quadrature level the RatioTran is driven at the .2 tap, stepping up the level by a factor of 5.

The output of the quadrature generator varies inversely proportional to frequency. A quadrature level control, R147, is part of the input resistance to enable the output to be adjusted to compensate for a frequency difference of more than $\pm 5\%$ of design center. An adjustable resistor, R152, is also a part of the input resistance. It is used to center the range of the quadrature level control.

### QUADRATURE AND IN-PHASE RATIO SUMMING

The adjustable arms of the two RatioTrans (in-phase and quadrature) are connected together, causing the amplifier common to have a potential which is the sum of the two RatioTran outputs with respect to the reference input common. The sum of the ratios creates a complex ratio which can be made to exactly equal the ratio under test.

### REFERENCE AMPLIFIER

The reference amplifier and transformer T106 supply the push-pull reference voltage to the phase-sensitive detector. Q110, Q111 and Q112 are connected as a feedback controlled amplifier. REFERENCE LEVEL, R160, controls the amount of feedback and therefore the overall gain. In order to maintain an output level of approximately 1v rms, the required gain is inversely proportional to the bridge signal source. The REFERENCE LEVEL control is calibrated such that when set to correspond to the signal source level used, the amplifier output will be about 1v rms. A small deviation from this value will in effect change only the maximum meter deflection and not materially affect the sensitivity.

THE IN-PHASE/QUADRATURE switch selects the signal applied to the amplifier. The in-phase signal is from a winding of the reference input transformer and the quadrature signal from the center tap on the quadrature RATIOTRAN. Both sources will be .05 times the bridge signal source (REFERENCE INPUT). The test jacks J113 and J114 at the amplifier input are used to compare the amplitudes of the two signals in pre-use calibration.

### NULL AMPLIFIER

The signal input is applied to a compensated divider consisting of R101, R102, and R103 which attenuates the signal by a factor of ten. In this way the input impedance of the null amplifier can never be less than the one megohm resistor R101 even when the signal is large enough to overload the input emitter followers.

The null amplifier consists of Q101 through Q106. Q101 and Q102 are emitter followers 'bootstrapped' to raise the input impedance to approximately one megohm. The back-biased diodes CR101 and CR102 are to prevent damage to the transistors with large off-null signals. The following voltage amplifiers consists of two sets of amplifiers connected as 'feedback pairs'. Such a connection provides a large measure of DC feed back to stabilize the operating point. An overall gain of approximately 75DB is realized and the frequency response is flat from 50 cps to 10 kc.

The maximum signal output to the phase-sensitive detector is about one volt rms before limiting occurs. The limiting action prevents damage to the sensitive null meter.

## POWER SUPPLY

The CRB-4 is essentially a battery operated instrument. The battery is a 12V, 500 mah nickel-cadium, rechargeable type. It is kept on constant trickle charge when instrument is operated from the power line. The amplifier current drain is approximately 20 ma which should give up to 25 hours of operation on a fully charged battery. When the power switch is in the battery check position, the null meter is converted to a voltmeter to measure the battery voltage. The voltmeter is so calibrated as to read on the red lines when the battery has 10% charge remaining.

The power line charging source is a full wave bridge rectifier and a shielded power transformer with low inter-winding capacity. The low inter-winding capacity is necessary because of the 'floating' chassis. Capacity between the primary and secondary appears as a load on the vector ratio generated in the CRB-4.

The power transformer primary is wound with two equal 115V windings that can be connected either in parallel for 115V operation or in series for 230V. Binding posts and straps are provided for a simple change over to either voltage. (see figure 7). The unit is normally connected for 115V AC using a .1 amp. fuse. For 230V AC operation, the fuse should be changed to .06 amp.

Switch S107 (FAST CHARGE) increases the charging rate from a trickle charge to a fast charge when the CRB-4 power switch is in the off position. Indicator lamp DS101 will be on when the switch is in the fast charge position.

Terminals are provided in the rear of the chassis to charge the battery from a 28V DC source. The 28V DC supply must be disconnected in order to operate the bridge.

Fig. 8 (page 11) is a tabulation of the charging rates used in the CRB-4.

BATTERY SUBSITUTE. — Units not to be used for portable operation can be modified to operate on AC only. This is accomplished by replacing the battery with a 12V regulating unit (Z101 on parts list).

The regulating unit consists of a zener diode-capacitance network and serves to limit the voltage output to 12V DC.

## REFERENCE INPUT CONNECTOR

In the CRB-4, one side of the REFERENCE INPUT is connected through a jumper wire to case ground. In some applications it may be desirable to have the reference source isolated to avoid ground loops. The jumper is between connections 3 and 4 on the rear of the IN-PHASE RATIOTRAN. It is only necessary to cut this jumper to obtain complete isolation.

A tri-axial type connector was chosen to enable the shield to be isolated as it passes through the front panel. This connector is designed to handle a double shielded cable with the inner shield completely isolated from the outer shield and connector housing. Ordinary co-axial cable WILL NOT fit the connector and a smaller size must be used. The type of cable recommended is AMPHENOL 21-597 (subminax). Fig. 11 on page 15 is an assembly drawing showing how to assemble the connector with the recommended co-axial cable.

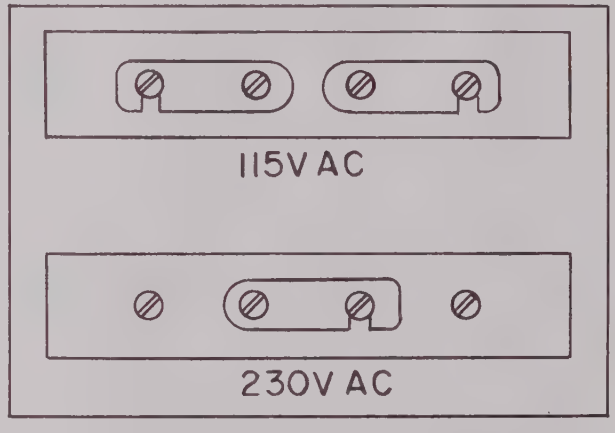



FIGURE 7. 115/230 VAC CONNECTIONS

# SECTION IV
# MAINTENANCE

## MAINTENANCE AND AMPLIFIER ADJUSTMENTS

GERTSCH PRODUCTS will supply replacement components at current net prices. However, a large majority of the components used are standard parts obtainable from your local electronics parts dealer. Make certain of the required tolerances by consulting parts list.

## GENERAL

Replacement of transistors and components in most circuits of the CRB-4 will not materially effect the overall operation of the unit. The one exception will be in the quadrature generator circuit. As stated in the section dealing with the quadrature angular accuracy (page 8) a phase error in the quadrature can effect the accuracy of both the in-phase and quadrature read-out. An adjustable phase correcting network consisting of R148 and C121 is placed in the input circuit. Phase error due to quadrature generator loading, transistor gain variation, etc., can thus be compensated for.

## MAINTENANCE EQUIPMENT

The equipment needed to perform a complete recalibration and adjustment is as follows:

1. AC VTVM (H. P. 400C or equiv.)
2. Signal generator (H. P. 200 CD or equiv.)
3. Variable phase generator (G.P.I. VPS-1 or equiv.)

## UNITY ADJUSTMENT

Due to loading, the transformation ratio of the isolation

transformer secondary used to drive the in-phase RatioTran is slightly less than unity. A compensating circuit consisting of T107 and R167 is adjusted to correct this small error. The procedure is as follows:

1. Set up bridge as per operating instructions.
2. Place probe on high side of reference input signal source.
3. Null bridge as per operating instructions.
4. Adjust R167 to make the in-phase RatioTran read exactly 1.00000 at null.

## QUADRATURE GENERATOR

The following is a step by step procedure for adjusting and calibrating the quadrature generator.

1. Set POWER switch to 'on'.
2. Connect signal source of 20v rms, 400 cps ±1 cps to REFERENCE INPUT.
3. Set REFERENCE LEVEL control to 20 volts.
4. Set both RATIOTRANS to zero.
5. Connect AC VTVM to test points directly below IN-PHASE/QUADRATURE switch.
6. Set QUADRATURE LEVEL control to mid position (pointer vertical)
7. Note VTVM reading when IN-PHASE/QUADRATURE switch is in the IN-PHASE position.
8. Change IN-PHASE/QUADRATURE switch to the QUADRATURE position and adjust R152 to obtain the exact same reading as in the IN-PHASE position.
9. Change REFERENCE LEVEL control to read 50.
10. Replace signal source with REFERENCE OUTPUT of Gertsch VPS-1.
11. Perform step 6 of operating instructions.
12. Place CRB-4 0°-180° switch in the 0° position.
13. Place CRB-4 90°-270° switch in the 90° position.
14. Set IN-PHASE RATIO switch to X1 position.
15. Set IN-PHASE RATIOTRAN of VPS-1 to zero.
16. Set QUADRATURE RATIOTRAN of VPS-1 to .090000.
17. Set VECTOR ATTENUATOR of VPS-1 to 1.000.
18. Set QUADRANT SELECTOR of VPS-1 to 0°-90°.
19. Connect probe of CRB-4 to VECTOR OUTPUT of VPS-1 and adjust CRB-4 ratiotrans to obtain null as outlined in operating instructions.
20. Adjust R148 to make the IN-PHASE RATIOTRAN read between 0 and 5 on last dial position (.00005 max) when both RATIOTRANS are again adjusted for null. The quadrature accuracy is then within the tolerance of the VPS-1.

Various angles between 0° and 5° can be set up on the VPS-1 and measured with the CRB-4 as a spot check. The CRB-4 read-out is in the rectangular form Rx + jRy where Rx is the in-phase ratio and Ry the quadrature ratio. The tangent Ry/Rx is computed and reference to a standard trig. table will give the angle as measured by the CRB-4. The measured angle should be within ±3 minutes of the angle generated by the VPS-1.

## REFERENCE LEVEL

The REFERENCE LEVEL control is calibrated as follows:

1. Set POWER switch to 'on'.
2. Connect signal source of 20v rms, 400 cps ±5% to REFERENCE INPUT.
3. Set all RATIOTRANS to zero.
4. Set IN-PHASE/QUADRATURE switch to the IN-PHASE position.
5. Connect AC VTVM between emitter of Q112 and chassis.
6. Adjust REFERENCE LEVEL control to read 1 vrms ±5% on AC VTVM.
7. Loosen control set screws and position control pointer to read 20, and re-tighten set screws.

## NULL AMPLIFIER GAIN

The null amplifier gain can vary somewhat with transistor replacement. The gain may be adjusted by changing the value of R115. R115 may be any value from 150 ohms to 390 ohms. The gain is set at the factory by using a REFERENCE INPUT of 20 vrms. With the probe connected to reference common, a setting of 3 on the last IN-PHASE RATIOTRAN dial (.00003) and zero QUADRATURE, should give a meter deflection of between 3 and 4 divisions. If the meter reading is greater than 4, R115 is increased, and decreased if less than 3.

A higher gain is not recommended because the inherent circuit noise will tend to obscure the correct null.

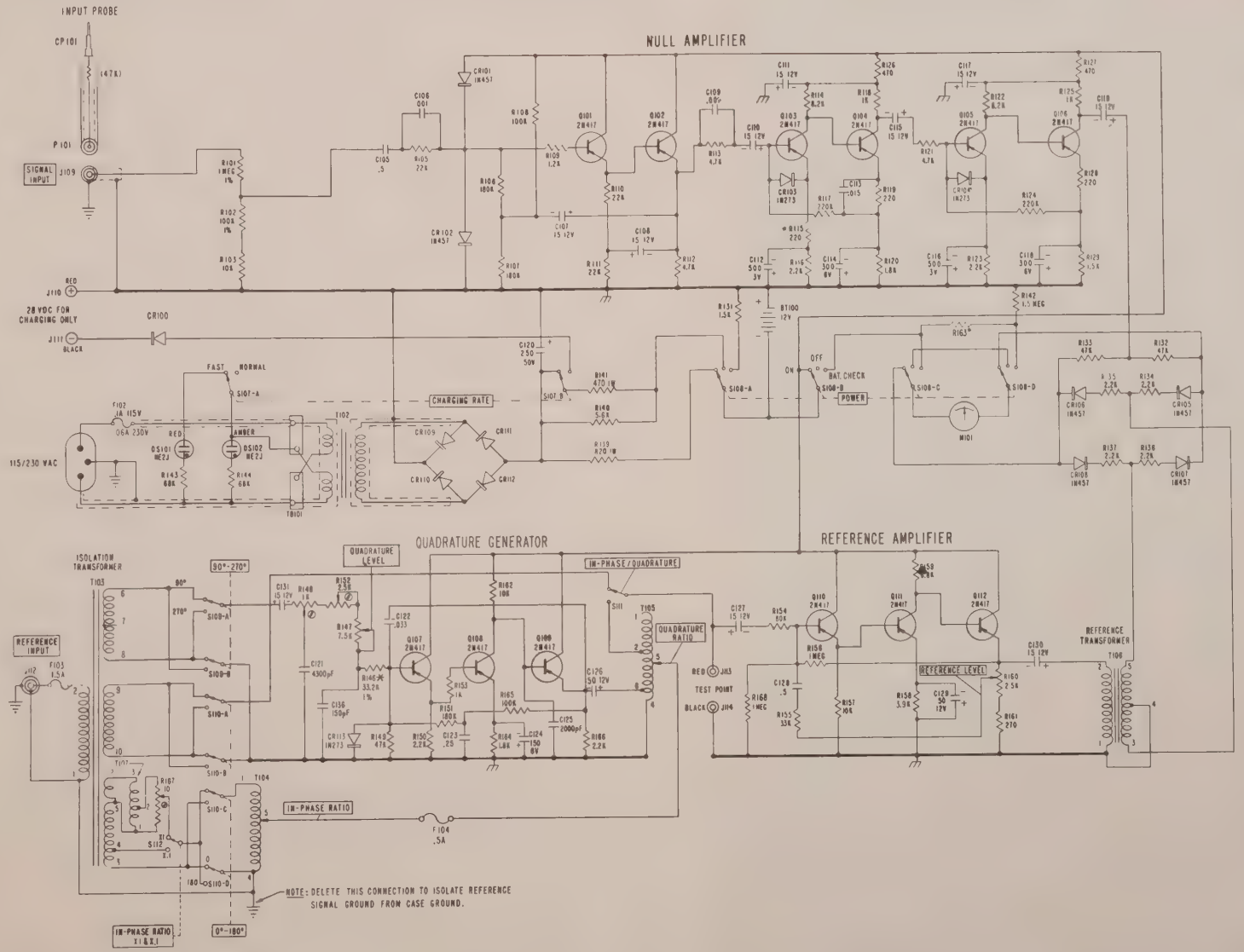
## BATTERY CHARGING RATES

The minimum charging time for a completely discharged battery is 750 mah and the maximum charging rate is 75 ma with maximum prolonged over charge rate of 40 ma.

The following is tabulation of the charging rates used in the CRB-4.

| Power Switch Position | Fast Charge Switch Position | Charging Source | Charging Rate |
|---|---|---|---|
| Off | Normal | 115VAC | 5 ma |
| Off | Fast Charge | 115VAC | 40 ma |
| On | Normal or Fast Charge | 115VAC | 5 ma |
| Off | Normal | 28VDC | 40 ma |
| Off | Fast Charge | 28VDC | None |

FIGURE 8. BATTERY CHARGING RATES




NOTES:

1. ALL RESISTORS ARE 1/2 WATT AND IN OHMS ±10% UNLESS OTHERWISE SPECIFIED.
2. ALL CAPACITORS ARE IN μF UNLESS OTHERWISE SPECIFIED
3. THIS SCHEMATIC EFFECTIVE ON ALL UNITS HAVING SERIAL NO. 251 AND UP.

* VALUE SELECTED AT FACTORY (MAY BE OMITTED)

FIGURE 9. SCHEMATIC DIAGRAM

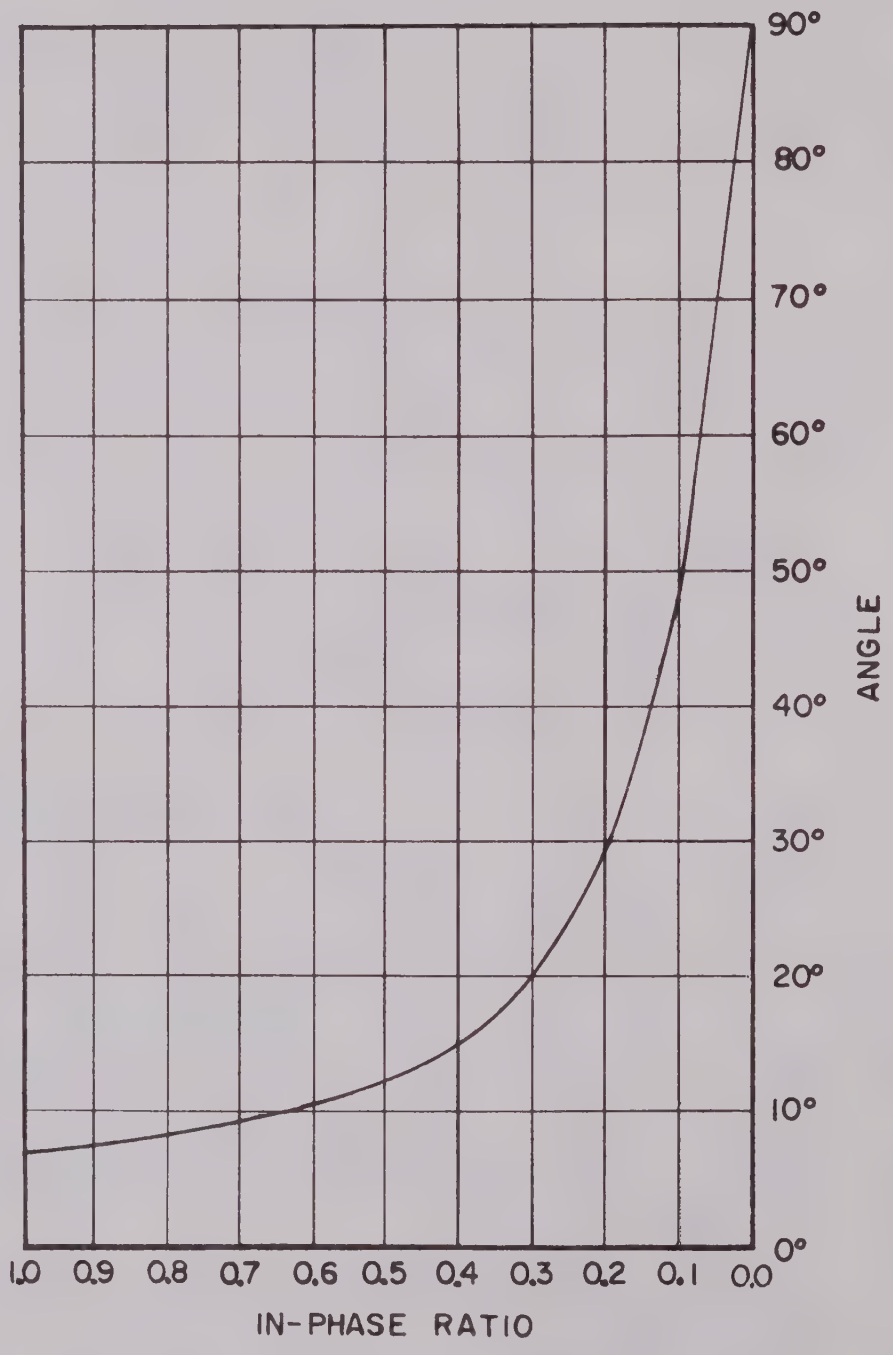



FIGURE 10. MAXIMUM ANGLE MEASUREMENT

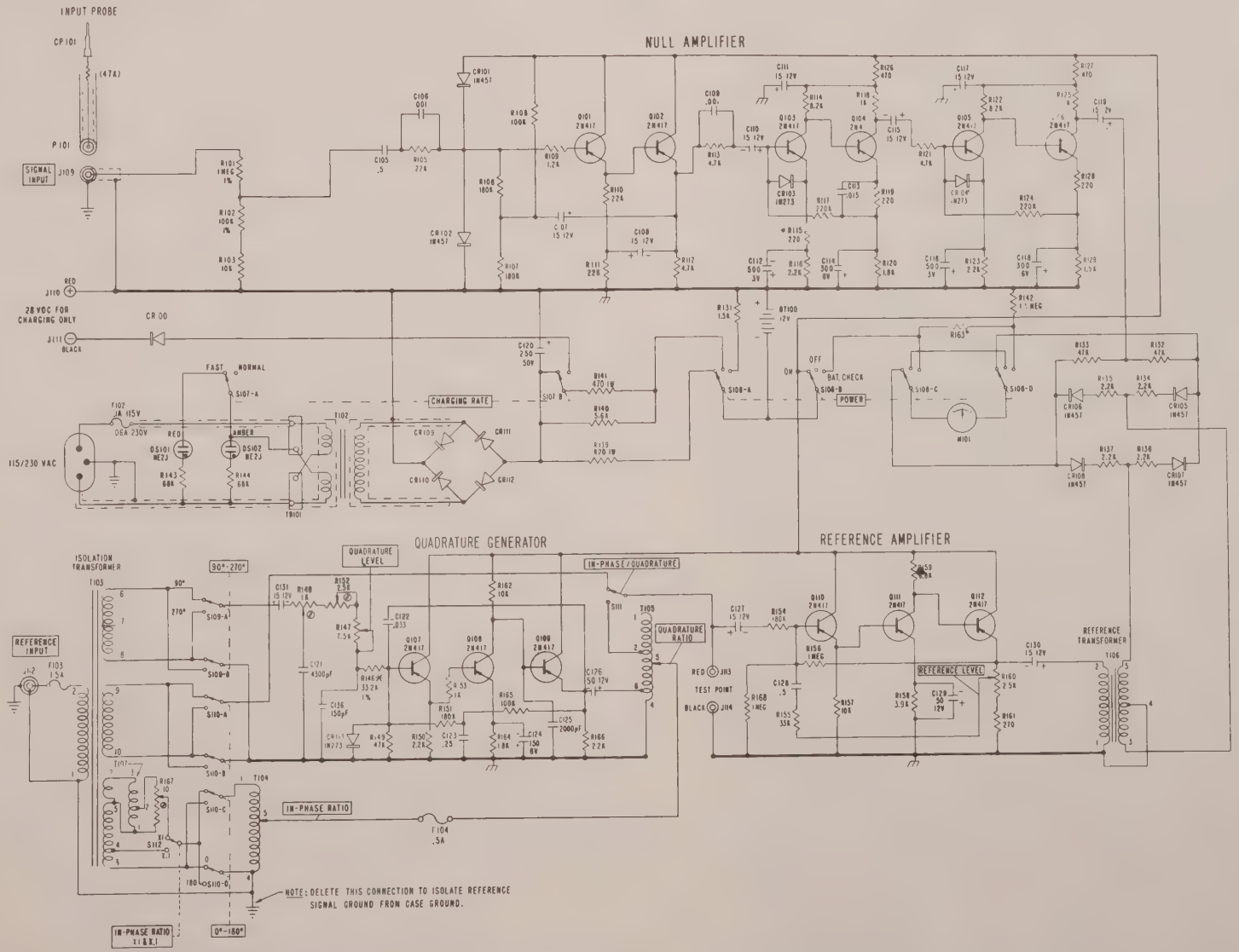



FIGURE 9. SCHEMATIC DIAGRAM

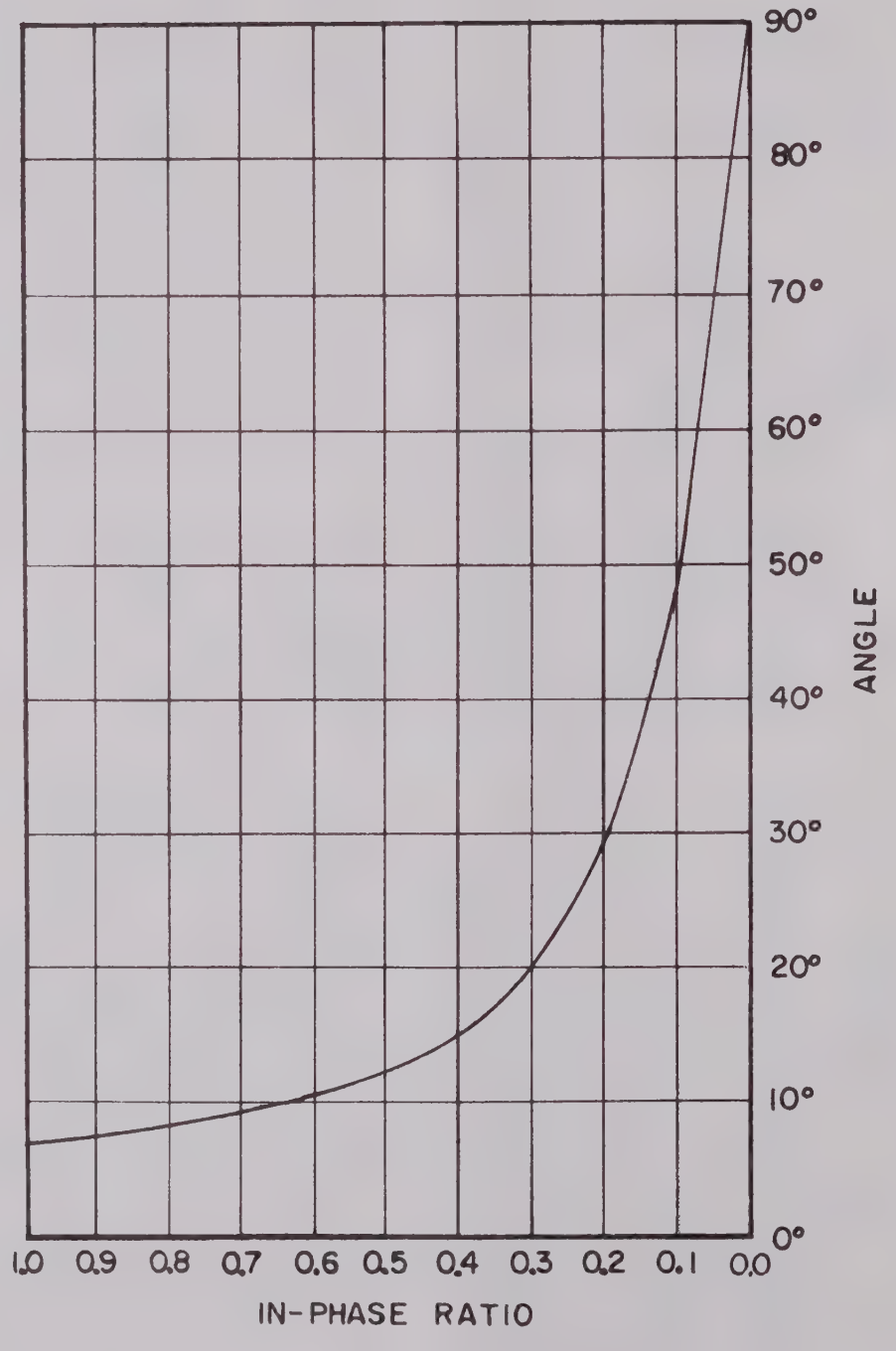



FIGURE 10. MAXIMUM ANGLE MEASUREMENT

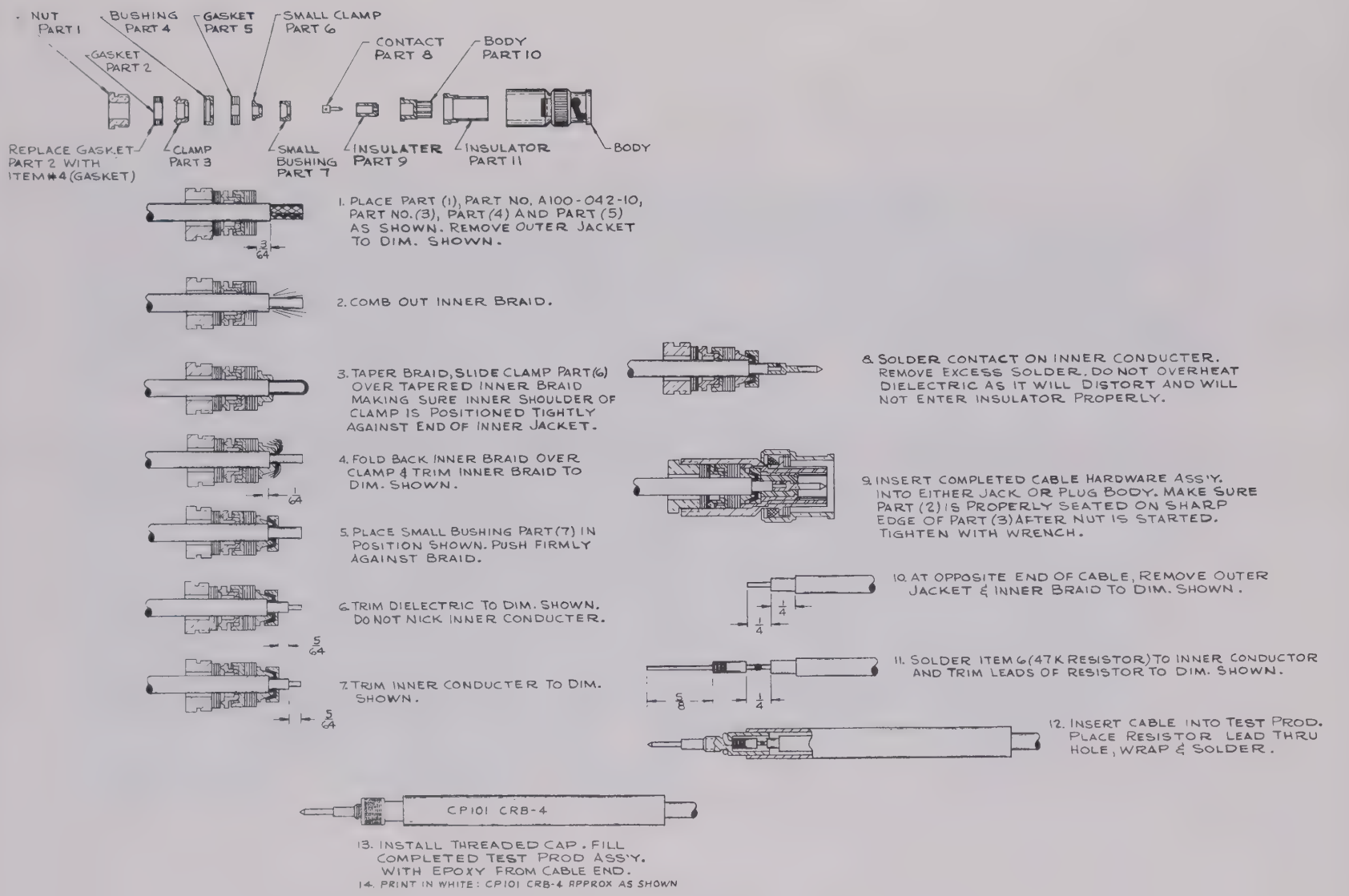

NUT PART 1
BUSHING PART 4
GASKET PART 5
SMALL CLAMP PART 6
GASKET PART 2
CONTACT PART 8
BODY PART 10
REPLACE GASKET PART 2 WITH ITEM #4 (GASKET)
CLAMP PART 3
SMALL BUSHING PART 7
INSULATER PART 9
INSULATOR PART 11
BODY
1. PLACE PART (1), PART NO. A100-042-10, PART NO. (3), PART (4) AND PART (5) AS SHOWN. REMOVE OUTER JACKET TO DIM. SHOWN.
2. COMB OUT INNER BRAID.
3. TAPER BRAID, SLIDE CLAMP PART (6) OVER TAPERED INNER BRAID MAKING SURE INNER SHOULDER OF CLAMP IS POSITIONED TIGHTLY AGAINST END OF INNER JACKET.
4. FOLD BACK INNER BRAID OVER CLAMP & TRIM INNER BRAID TO DIM. SHOWN.
5. PLACE SMALL BUSHING PART (7) IN POSITION SHOWN. PUSH FIRMLY AGAINST BRAID.
6. TRIM DIELECTRIC TO DIM. SHOWN. DO NOT NICK INNER CONDUCTER.
7. TRIM INNER CONDUCTER TO DIM. SHOWN.
8. SOLDER CONTACT ON INNER CONDUCTER. REMOVE EXCESS SOLDER. DO NOT OVERHEAT DIELECTRIC AS IT WILL DISTORT AND WILL NOT ENTER INSULATOR PROPERLY.
9. INSERT COMPLETED CABLE HARDWARE ASS'Y. INTO EITHER JACK OR PLUG BODY. MAKE SURE PART (2) IS PROPERLY SEATED ON SHARP EDGE OF PART (3) AFTER NUT IS STARTED. TIGHTEN WITH WRENCH.
10. AT OPPOSITE END OF CABLE, REMOVE OUTER JACKET & INNER BRAID TO DIM. SHOWN.
11. SOLDER ITEM 6 (47K RESISTOR) TO INNER CONDUCTOR AND TRIM LEADS OF RESISTOR TO DIM. SHOWN.
12. INSERT CABLE INTO TEST PROD. PLACE RESISTOR LEAD THRU HOLE, WRAP & SOLDER.
CP101 CRB-4
13. INSTALL THREADED CAP. FILL COMPLETED TEST PROD ASS'Y. WITH EPOXY FROM CABLE END.
14. PRINT IN WHITE: CP101 CRB-4 APPROX AS SHOWN

FIGURE 11. CONNECTOR ASSEMBLY

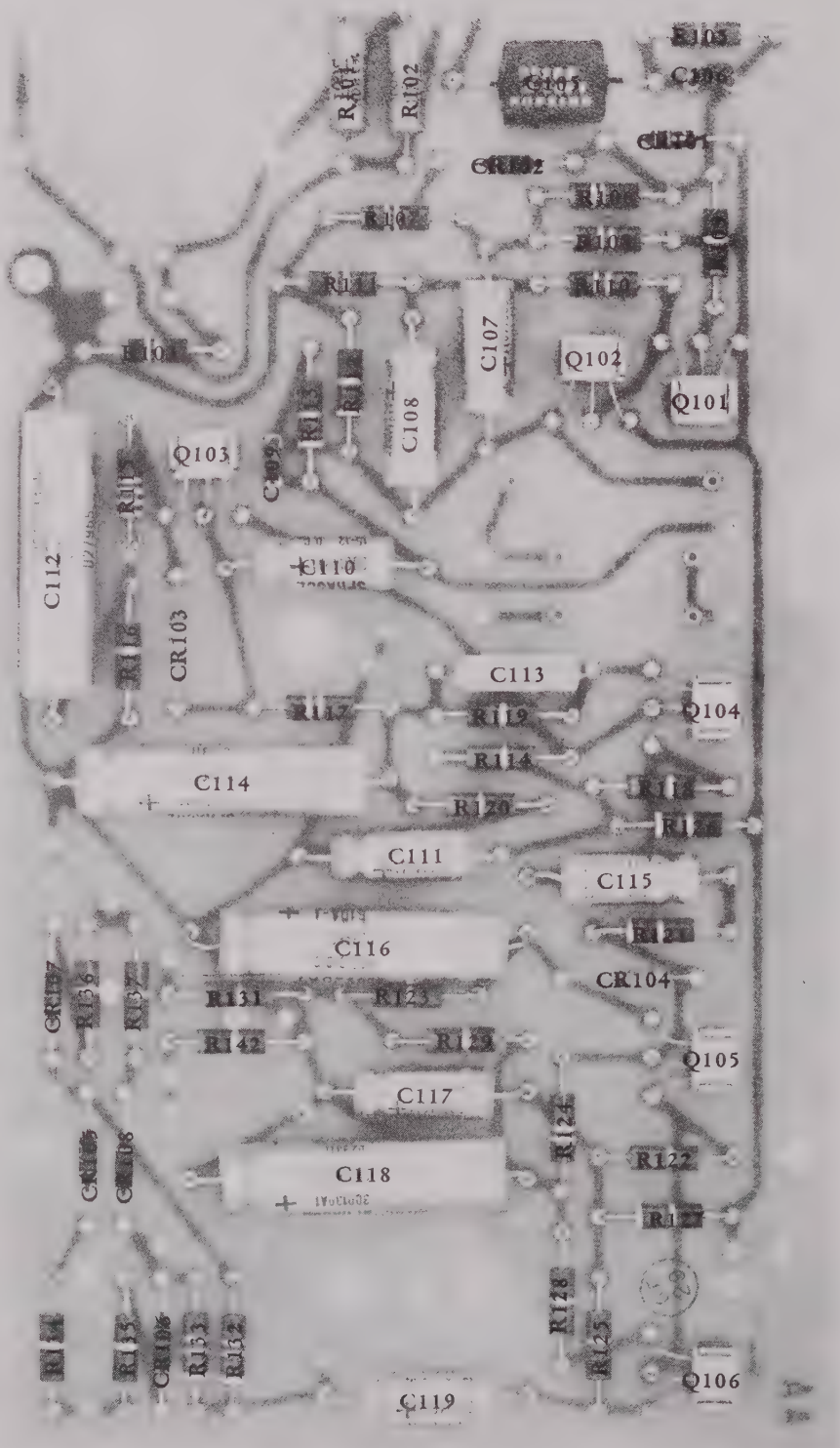



FIGURE 12. BOARD ASSEMBLY — A1, NULL AMPLIFIER

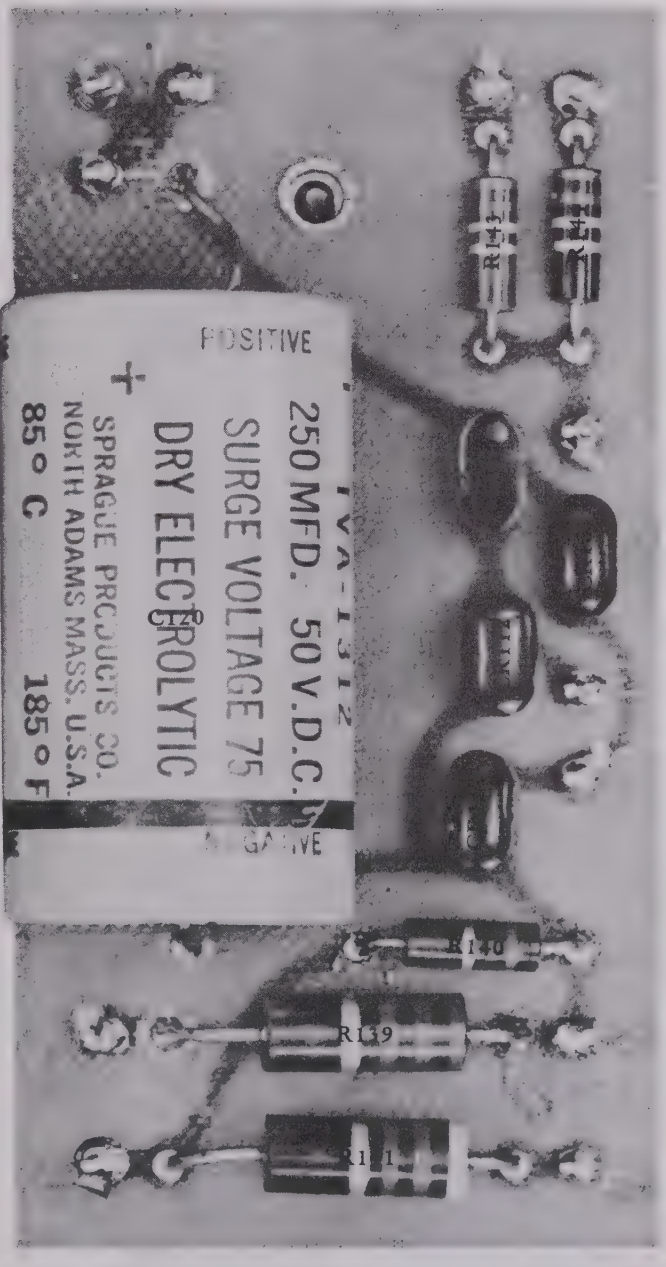



FIGURE 13. BOARD ASSEMBLY — A2, POWER SUPPLY

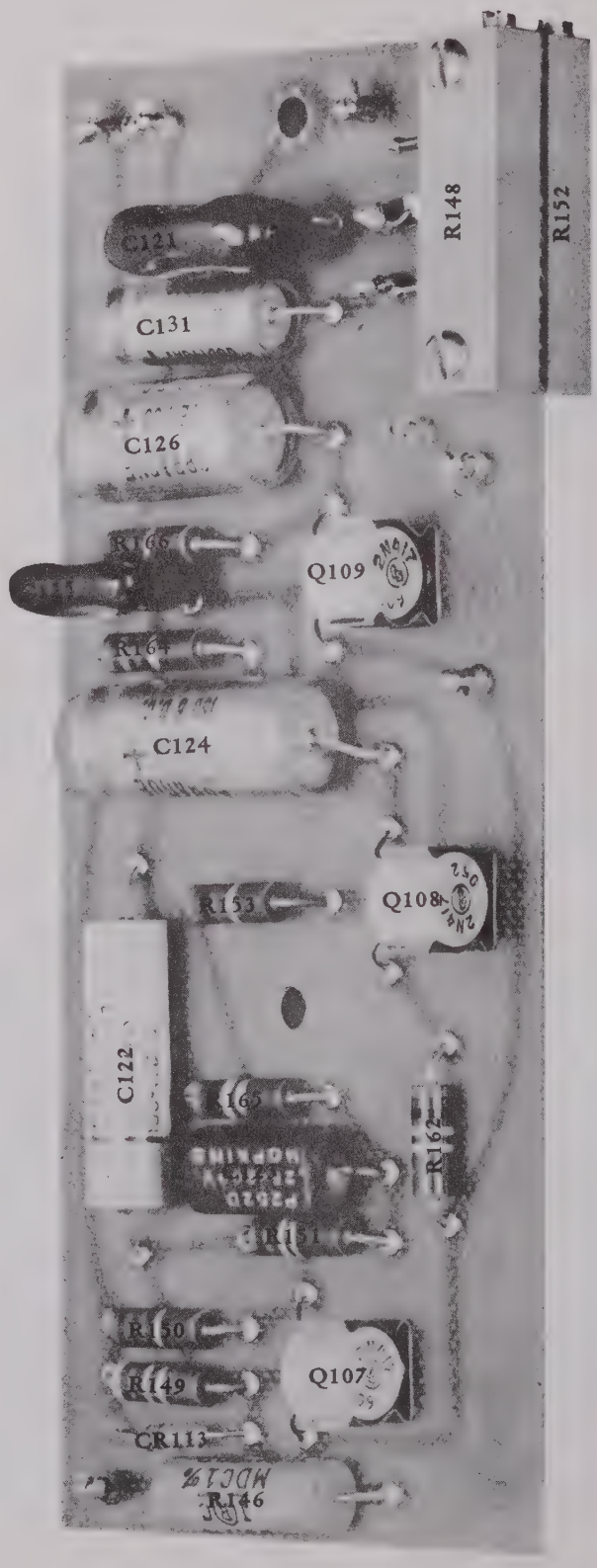



FIGURE 14. BOARD ASSEMBLY — A3, QUADRATURE GENERATOR

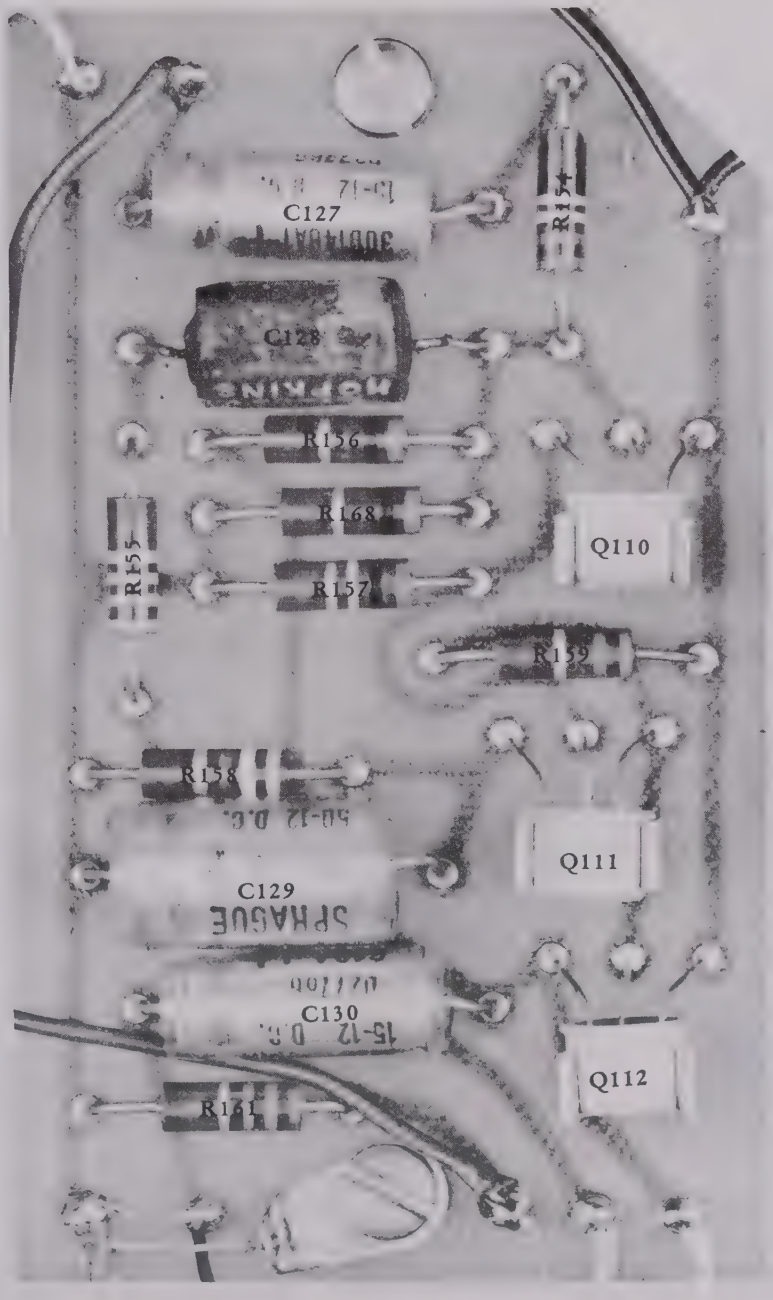



FIGURE 15. BOARD ASSEMBLY — A4, REFERENCE AMPLIFIER

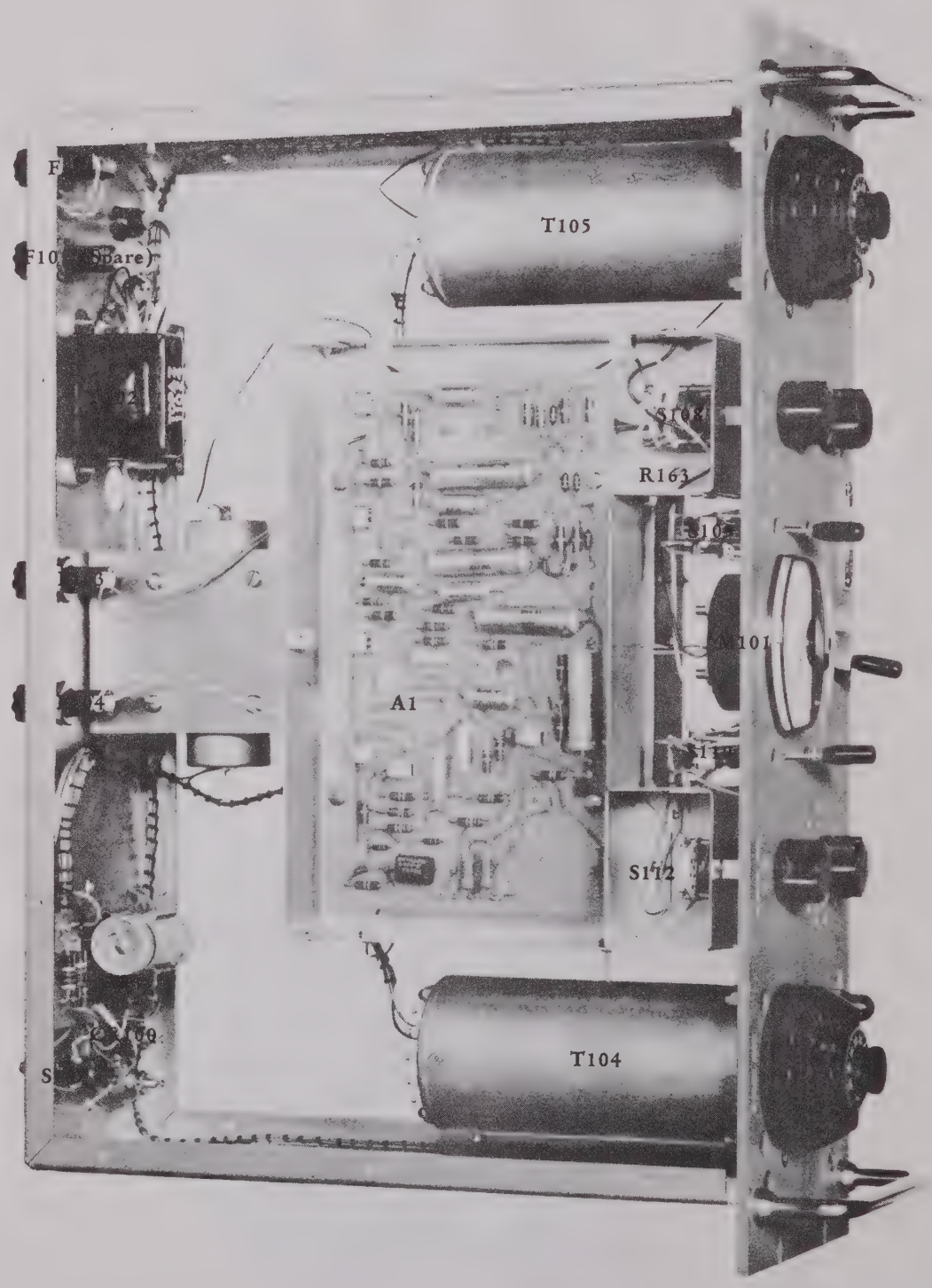



FIGURE 16. PARTS LOCATION — TOP VIEW

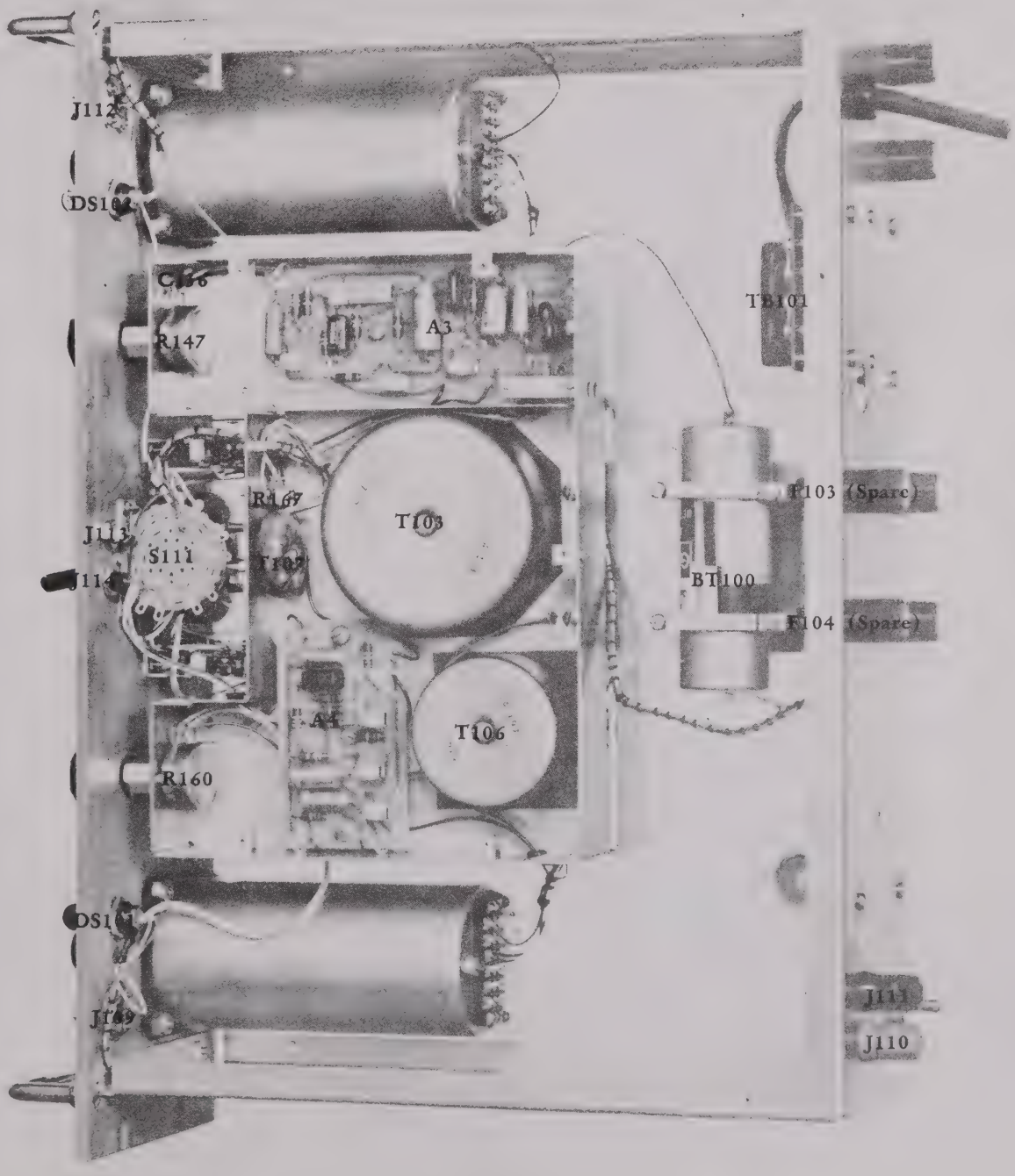



FIGURE 17. PARTS LOCATION — BOTTOM VIEW

# SECTION V
# PARTS LIST

| SYM-BOL | DESCRIPTION | MANUFACTURER | PART NO. |
|---|---|---|---|
| BT100 | Battery | Gulton Ind. Inc. | 10 VO .500 |
| C105 | Capacitor, metalized paper .5 uF 200V | Hopkins Eng. Co. | P52DS |
| C106 | Capacitor, disc ceramic .001 uF | Erie | 861Z5U102Z |
| C107 | Capacitor, electrolytic 15 uF 12V | Sprague | TE-1129 |
| C108 | Capacitor, electrolytic 15uF 12V | Sprague | TE-1129 |
| C109 | Capacitor, disc ceramic .001 uF | Erie | 861Z5U102Z |
| C110 | Capacitor, electrolytic 15 uF 12V | Sprague | TE-1129 |
| C111 | Capacitor, electrolytic 15 uF 12V | Sprague | TE-1129 |
| C112 | Capacitor, electrolytic 500 uF 3V | Sprague | TE-1068 |
| C113 | Capacitor, mylar .015 uF 10% 200V | Goodall | 663UW-015UF200V |
| C114 | Capacitor, electrolytic 300 uF 6V | Sprague | TE-1106 |
| C115 | Capacitor, electrolytic 15 uF 12V | Sprague | TE-1129 |
| C116 | Capacitor, electrolytic 500 uF 3V | Sprague | TE-1068 |
| C117 | Capacitor, electrolytic 15 uF 12V | Sprague | TE-1129 |
| C118 | Capacitor, electrolytic 300 uF 6V | Sprague | TE-1106 |
| C119 | Capacitor, electrolytic 15 uF 12V | Sprague | TE-1129 |
| C120 | Capacitor, electrolytic 250 uF 50V | Sprague | TVA-1312 |
| C121 | Capacitor, silvered mica 4300pF | El-Menco | DM20E432J |
| C122 | Capacitor, polystyrene .033uF 100V | West-Cap | WR94J1333 |
| C123 | Capacitor, metalized paper .25uF 200V | Hopkins Eng. Co. | P252D |
| C124 | Capacitor, electrolytic 150uF 6V | Sprague | TE-1103 |
| C125 | Capacitor, silvered mica 2000pF | El-Menco | DM19E202J |
| C126 | Capacitor, electrolytic 50 uF 12V | Sprague | TE-1133 |
| C127 | Capacitor, electrolytic 15 uF 12V | Sprague | TE-1129 |
| C128 | Capacitor, metalized paper .5 uF 200V | Hopkins Eng. Co. | P52DS |
| C129 | Capacitor, electrolytic 50 uF 12V | Sprague | TE-1133 |
| C130 | Capacitor, electrolytic 15 uF 12V | Sprague | TE-1129 |
| C131 | Capacitor, electrolytic 15uF 12V | Sprague | TE-1129 |
| C136 | Capacitor, mica 150pF | Elmenco | DM15E151J |
| CR100 | Diode, silicon | Diodes Inc. | DI-56 |
| CR101 | Diode, silicon | Hughes | IN457 |
| CR102 | Diode, silicon | Hughes | IN457 |
| CR103 | Diode, germanium | Transitron | IN273 |
| CR104 | Diode, germanium | Transitron | IN273 |

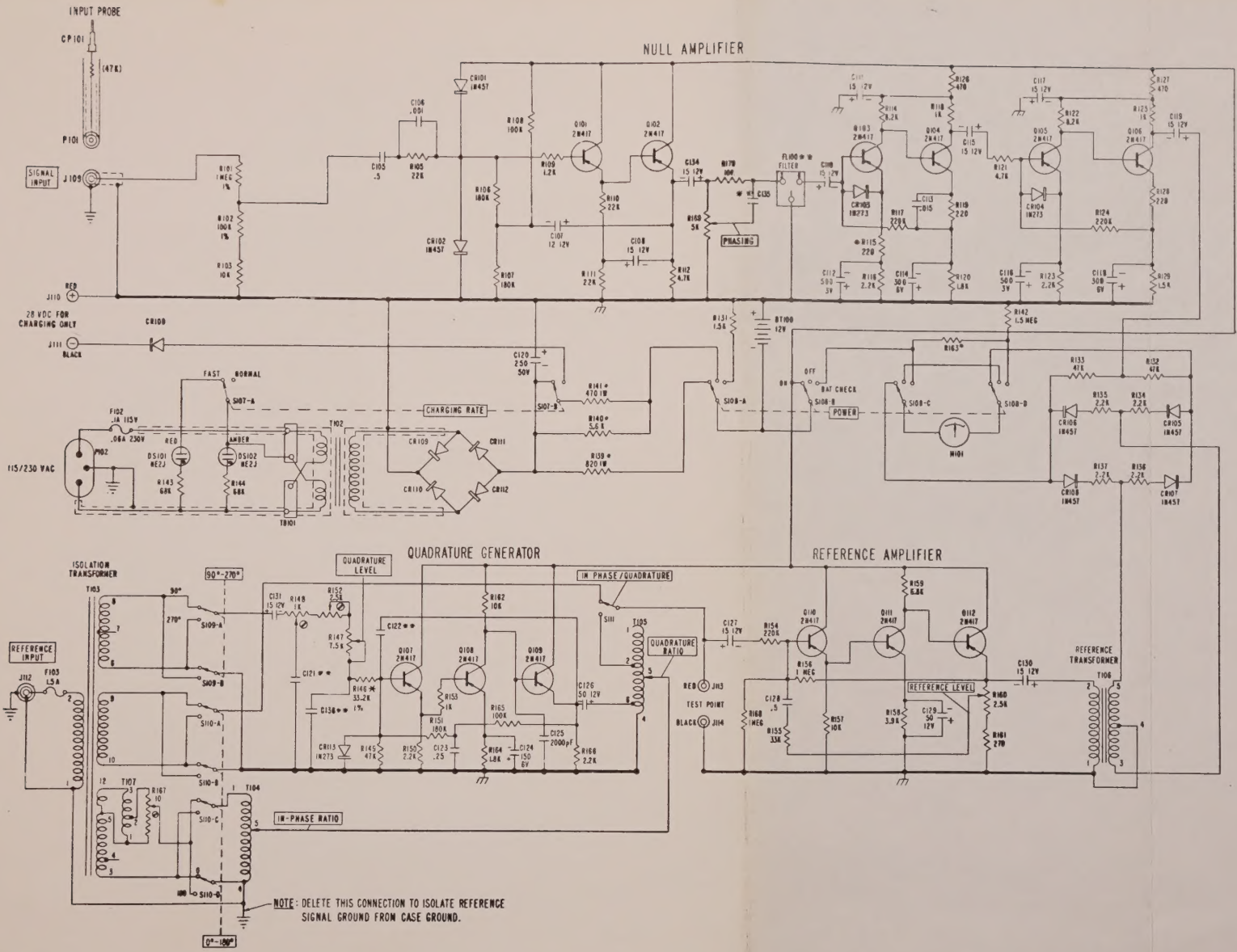
| SYM-BOL | DESCRIPTION | MANUFACTURER | PART NO. |
|---|---|---|---|
| CR105 | Diode, silicon | Hughes | IN457 |
| CR106 | Diode, silicon | Hughes | IN457 |
| CR107 | Diode, silicon | Hughes | IN457 |
| CR108 | Diode, silicon | Hughes | IN457 |
| CR109 | Diode, silicon | Semtec | SC2 |
| CR110 | Diode, silicon | Semtec | SC2 |
| CR111 | Diode, silicon | Semtec | SC2 |
| CR112 | Diode, silicon | Semtec | SC2 |
| CR113 | Diode, germanium | Transitron | IN273 |
| DS101 | Lamp, neon | General Elec. | NE-2J |
| DS102 | Lamp, neon | General Elec. | NE-2J |
| F102 | Fuse, slow blowing, 2 required (one spare)<br>.1A for 115V operation<br>.06A for 230V operation | Bussmann Mfg. | <br>MDL 1/10<br>MDL 1/16 |
| F103 | Fuse, slow blowing, 2 required (one spare) 1.5A | Bussmann Mfg. | MDL 1-½ |
| F104 | Fuse, slow blowing, 2 required (one spare) .5A | Bussmann Mfg. | MDL 1-2 |
| J109 | Connector, panel, signal | GPI | EA113 |
| J110 | Post, binding, red | Superior Elec. | DF 30RC |
| J111 | Post, binding, black | Superior Elec. | DF 30BC |
| J112 | Connector, panel, reference | GPI | EA113 |
| J113 | Jack, test, red | Johnson | 108902 |
| J114 | Jack, test, black | Johnson | 108903 |
| M101 | Meter, null | GPI | AW-262 |
| Q101-112 | Transistor, 12 required | Tung-Sol | 2N417 |
| R101 | Resistor, deposited carbon 1M 1% ¼W | | RN65B1004F |
| R102 | Resistor, deposited carbon 100K 1% ¼W | | RN65B1003F |
| R103 | Resistor, composition 10K 10% ½W | | |
| R105 | Resistor, composition 22K 10% ½W | | |
| R106 | Resistor, composition 180K 10% ½W | | |
| R107 | Resistor, composition 180K 10% ½W | | |
| R108 | Resistor, composition 100K 10% ½W | | |
| R109 | Resistor, composition 1.2K 10% ½W | | |
| R110 | Resistor, composition 22K 10% ½W | | |
| R111 | Resistor, composition 22K 10% ½W | | |
| R112 | Resistor, composition 4.7K 10% ½W | | |
| R113 | Resistor, composition 4.7K 10% ½W | | |
| R114 | Resistor, composition 8.2K 10% ½W | | |

| SYM-BOL | DESCRIPTION | MANUFACTURER | PART NO. |
|---|---|---|---|
| R115 | Resistor, composition factory selected 220 ohms 10% ½W (nom) | | |
| R116 | Resistor, composition 2.2K 10% ½W | | |
| R117 | Resistor, composition 220K 10% ½W | | |
| R118 | Resistor, composition 1K 10% ½W | | |
| R119 | Resistor, composition 220 ohms 10% ½W | | |
| R120 | Resistor, composition 1.8K 10% ½W | | |
| R121 | Resistor, composition 4.7K 10% ½W | | |
| R122 | Resistor, composition 8.2K 10% ½W | | |
| R123 | Resistor, composition 2.2K 10% ½W | | |
| R124 | Resistor, composition 220K 10% ½W | | |
| R125 | Resistor, composition 1K 10% ½W | | |
| R126 | Resistor, composition 470 ohms 10% ½W | | |
| R127 | Resistor, composition 470 ohms 10% ½W | | |
| R128 | Resistor, composition 220 ohms 10% ½W | | |
| R129 | Resistor, composition 1.5K 10% ½W | | |
| R131 | Resistor, composition 1.5K 10% ½W | | |
| R132 | Resistor, composition 47K 10% ½W | | |
| R133 | Resistor, composition 47K 10% ½W | | |
| R134 | Resistor, composition 2.2K 10% ½W | | |
| R135 | Resistor, composition 2.2K 10% ½W | | |
| R136 | Resistor, composition 2.2K 10% ½W | | |
| R137 | Resistor, composition 2.2K 10% ½W | | |
| R139 | Resistor, composition 820 ohms 10% 1W | | |
| R140 | Resistor, composition 5.6K 10% ½W | | |
| R141 | Resistor, composition 470 ohms 10% ½W | | |
| R142 | Resistor, composition 1.5M 10% ½ W | | |
| R143 | Resistor, composition 68K 10% ½W | | |
| R144 | Resistor, composition 68K 10% ½W | | |
| R146 | Resistor, deposited carbon 33.2K 1% ¼W (nom value) | | RN65B3322F |
| R147 | Potentiometer, composition 7.5K 10% | GPI | RV-42-3 |
| R148 | Potentiometer, composition 1K trimmer | Allen Bradley | RS102U |
| R149 | Resistor, composition 47K 10% ½W | | |
| R150 | Resistor, composition 2.2K 10% ½W | | |
| R151 | Resistor, composition 180K 10% ½W | | |
| R152 | Potentiometer, composition 2.5K trimmer | Allen Bradley | RS252U |
| R153 | Resistor, composition 1K 10% ½W | | |
| R154 | Resistor, composition 180K 10% ½W | | |
| R155 | Resistor, composition 33K 10% ½W | | |
| R156 | Resistor, composition 1M 10% ½W | | |

| SYM-BOL | DESCRIPTION | MANUFACTURER | PART NO. |
|---|---|---|---|
| R157 | Resistor, composition 10K 10% ½W | | |
| R158 | Resistor, composition 3.9K 10% ½W | | |
| R159 | Resistor, composition 6.8K 10% ½W | | |
| R160 | Potentiometer, composition 2.5K 10% | GPI | RV-42 |
| R161 | Resistor, composition 270 ohms 10% ½W | | |
| R162 | Resistor, composition 10K 10% ½W | | |
| R163 | Resistor, composition, factory selected | | |
| R164 | Resistor, composition 1.8K 10% ½W | | |
| R165 | Resistor, composition 100K 10% ½W | | |
| R166 | Resistor, composition 2.2K 10% ½W | | |
| R167 | Potentiometer, wire wound 10 ohms trimmer | Bourns | 200S-1-100 |
| R168 | Resistor, composition 1M 10% ½W | | |
| S107 | Switch, toggle DPDT | Carling | 2BL6273 |
| S108 | Switch, rotary 4P 3 position | GPI | SW-135 |
| S109 | Switch, lever 4PDT | Mallory | 6242 |
| S110 | Switch, lever 4PDT | Mallory | 6242 |
| S111 | Switch, lever 4PDT | Mallory | 6242 |
| S112 | Switch, rotary 4PDT | GPI | SW-97 |
| T102 | Transformer, power, 115/230 VAC pri | GPI | TA-262 |
| T103 | Transformer, isolation | GPI | TA-198 |
| T104 | RatioTran, in-phase | GPI | CRT-7 |
| T105 | RatioTran, quadrature | GPI | CRT-7 |
| T106 | Transformer, reference | GPI | TA-197 |
| T107 | Transformer, stepdown | GPI | TA-252 |
| TB101 | Terminal board with 4 screws See figure 7<br>Link, shorting, for TB101 (2 required) | Cinch<br>Cinch | 1774<br>5101P24 |
| XDS101 | Lampholder, red | Dialco | 145-5036-991 |
| XDS102 | Lampholder, amber | Dialco | 145-5036-993 |
| XF102 | Fuseholder 3AG miniature (2 required) | Littelfuse | 342004 |
| XF103 | Fuseholder 3AG miniature (2 required) | Littelfuse | 342004 |
| XF104 | Fuseholder 3AG miniature (2 required) | Littelfuse | 342004 |
| *Z101 | Battery substitute | GPI | AA826 |
| | Knob, lever switch, 3 required | GPI | OM-639 |
| | Knob, medium, 4 required | GPI | AA-537 |
| | Power cord | Belden | 17406-S |
| | Adaptor plug | Cornish | 228 |
| | Reference cable & connector assembly | GPI | WA25 |
| | Signal probe & cable assembly | GPI | WA17 |

SUBSTITUTIONS: When expedient, equivalent components may be substituted at the factory. Performance will not be impaired. When making replacements, either parts in this list or the substituted equivalent may be used.

*Non-portable units only




NOTES:

1. ALL RESISTORS ARE 1/2 WATT AND IN OHMS ±10% UNLESS OTHERWISE SPECIFIED.
2. ALL CAPACITORS ARE IN μF UNLESS OTHERWISE SPECIFIED:

* VALUE SELECTED AT FACTORY (MAY BE OMITTED).

| ** | REF DES | 400 CPS | 800 CPS |
|---|---|---|---|
| | C121 | 4300 pF | 2200 pF (NOM VALUE) |
| | C122 | .035 UF | .016 UF (NOM VALUE) |
| | C135 | .05 UF | .025 UF (NOM VALUE) |
| | C136 | 150 pF | 75 pF (NOM VALUE) |
| | FL100 | 8pF 400W | 8pF 800W |